SPECIAL REPORT

Range Commanders Council

SUSTAINABILITY GROUP

COMMANDERS GUIDE TO RENEWABLE ENERGY

WHITE SANDS MISSILE RANGE
REAGAN TEST SITE
YUMA PROVING GROUND
DUGWAY PROVING GROUND
ABERDEEN TEST CENTER
ELECTRONIC PROVING GROUND

NAVAL AIR WARFARE CENTER WEAPONS DIVISION, PT. MUGU
NAVAL AIR WARFARE CENTER WEAPONS DIVISION, CHINA LAKE
NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION, PATUXENT RIVER
NAVAL UNDERSEA WARFARE CENTER DIVISION, NEWPORT
PACIFIC MISSILE RANGE FACILITY
NAVAL UNDERSEA WARFARE CENTER DIVISION, KEYPORT

30TH SPACE WING
45TH SPACE WING
AIR FORCE FLIGHT TEST CENTER
AIR ARMAMENT CENTER
ARNOLD ENGINEERING DEVELOPMENT CENTER
BARRY M. GOLDWATER RANGE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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COMMANDERS GUIDE
TO RENEWABLE ENERGY

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TABLE OF CONTENTS

LIST OF FIGURES

PREFACE

This special report presents the results of Task SG-003, "*Commanders Guide - Renewable Energy Encroachment.*" The report was produced through a joint effort the Sustainability Group (SG) and the Signature Measurement Standards Group (SMSG) of the Range Commanders Council (RCC). Discussed herein are the impacts that renewable energy infrastructure projects (wind, solar, geothermal, biomass, nuclear, etc.) and off-range transmission have on the member range missions. Also included are tools and strategies for engaging local, state, and Federal agencies, as well as energy developers. Lastly, it will include a compendium of research efforts, studies, testing, and other documentation related to impacts of energy infrastructure on military testing and training.

The report will provide member ranges with information and tools they can use to ensure renewable energy infrastructure and transmission proposals are mission compatible. It will benefit all open-air ranges.

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ACRONYMS

AFB	Air Force Base
AGL	above ground level
ARRA	American Recovery and Reinvestment Act
AWEA	American Wind Energy Association
BLM	Bureau of Land Management
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
CSP	concentrating solar power
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DoD	Department of Defense
DOI	Department of the Interior
ESA	Endangered Species Act
F	Fahrenheit
FAA	Federal Aviation Administration
GIS	Geographical Information System
IR	infrared
MILREP	military representative
MOA	Memorandum of Agreement
MRTFB	Major Range and Test Facility Base
MTR	military training routes
MW	megawatt
NDAA	National Defense Authorization Act
NEPA	National Environmental Policy Act
NGO	non-governmental organizations
NHPA	National Historic Preservation Act
NOAA	National Oceanic and Atmospheric Agency
OCS	Outer Continental Shelf
OE/AAA	Obstruction Evaluation/Airport Airspace Analysis
OPR	Office of Primary Responsibility
OSD	Office of the Secretary of Defense
PEIS	Programmatic Environmental Impact Statement
PV	photovoltaic
RCC	Range Commanders Council
REC	Regional Environmental Coordinator
RETI	Renewable Energy Transmission Initiative
ROD	Record of Decision
ROW	right of way
RPS	renewable portfolio standard
SG	Sustainability Group
SME	subject matter expert
SREWG	Southwest Renewable Energy Work Group
SUA	special use airspace
U.S.	United States
USACE	U.S. Army Corps of Engineers

USCG	U.S. Coast Guard
USFS	U.S. Forest Service
WGEF	wind generated energy facility
WREZ	Western Renewable Energy Zones
WRP	Western Regional Partnership

COMMANDERS GUIDE TO RENEWABLE ENERGY

1 Range Commanders Council Sustainability Group

The mission of the Range Commanders Council (RCC) is to serve *"the technical and operational needs of U.S. test, training, and operational ranges*." The Sustainability Group (SG), founded in 2000, is one of many RCC workgroups. The SG goal is to equip its members with tools necessary to address encroachment issues so that they are aware of the latest best practices.

The SG meets twice a year to review and discuss the latest issues affecting the ability of installations and ranges to sustain their missions and shares tools for proactively addressing these concerns. The SG efforts focus on outreach, land use, urban sprawl and other sustainability areas (e.g., airspace and seaspace). The SG shares latest trends and approaches used to assist the military mission as well as recommending solutions to commanders.

Meetings are interactive and open to all military entities. Membership includes ranges and installations throughout the United States and is not limited to Major Range and Test Facility Base (MRTFB) installations. Meetings are open to all Department of Defense (DoD) personnel and include operators, sustainability professionals and community planners. This cross-sharing of information has proven to be helpful to member ranges and other DoD and non-DoD entities.

The SG developed several Commanders' Guides including *Community Involvement and Selected Best Practices and Lessons Learned*, and *Best Practices and Overview of State Legislative and Administrative Actions*. This guide to renewable energy is the next in the series.

2 Introduction

Renewable energy is a national imperative as well as a national security issue. However, renewable energy, whether developed on or off DoD land or waters, has the potential to negatively impact critical test and training missions. Installation and range commanders, major commands, Fleets, and their staffs must take steps to become aware early of pending renewable energy projects and become involved in the planning and siting of such projects and associated facilities to ensure mission compatibility.

Interest in renewable energy has increased dramatically during the last few years. The Energy Independence and Security Act of 2007, and Executive Orders 13423 (*Strengthening Federal Environmental, Energy, and Transportation Management*) and 13514 (*Federal Leadership in Environmental, Energy, and Economic Performance*) are key national policies. Previously, many states had renewable portfolio standards (RPSs) that required minimum percentages of energy consumed in the state to be from renewable sources. More recently, the American Recovery and Reinvestment Act of 2009 and other incentives promote renewable energy spending at a far more rapid pace.

Renewable energy comes in many forms including wind, solar, geothermal, hydro and biomass. Some forms of renewable energy have no mission impacts, but others have major

impacts. Wind turbines are typically 400 to 500 feet tall and create avoidance zones in low-level special use airspace (SUA) or military training routes. Offshore facilities could impact sea lanes, submarine transit lanes, and coastal test and training ranges. Such facilities have the potential to create sustained electromagnetic and acoustic interference that can negatively affect ground-based, shipborne, airborne, and submarine-borne sensors, communications, and navigational aids. Some types of solar facilities incorporate towers over 600 feet tall and there are plans for facilities with towers of several thousand feet. All renewable energy plants require transmission lines, which can limit aircraft from flying low in those areas, create electromagnetic interference and limit buffer zones. Even biomass and geothermal plants can have negative impacts.

All renewable energy projects have impacts on wildlife and habitat to some degree. Such impacts can include direct mortality, habitat fragmentation, clearing of vegetation, avoidance behavior from ground nesting birds like sage grouse, significant use of groundwater and other water sources (which in turn impacts wildlife and vegetation dependent on such water supplies), and other impacts. Such impacts from renewable energy projects on species listed as threatened or endangered under the Endangered Species Act, or species who are or may become candidates for such listing, or on habitat (occupied or unoccupied) for any such species can in turn result in additional restrictions on DoD where such species or their habitat are found on DoD installations or ranges.

Renewable energy is not just an issue off the installation or range. It is DoD policy to achieve on-base energy security to ensure continuity of operations. DoD has set a goal of twenty-five percent renewable energy sources by 2025. Often the military organizations responsible for developing on-base energy projects aren't aware of the potential mission impacts and plan projects without thorough coordination with mission proponents and with other relevant personnel, to include natural resource and environmental staffs.

3 Renewable Energy Basics

3.1 Wind Energy. A wind energy system transforms the kinetic energy of the wind into mechanical or electrical energy that can be harnessed for practical use. Mechanical energy is most commonly used for pumping water in rural or remote locations; the farm windmill still seen in many rural areas of the U.S. is a mechanical wind-driven water pumper. Wind electric turbines generate electricity for homes and businesses and for sale to utilities.

a. Basic Designs of Wind Electric Turbines. The two basic designs of wind electric turbines are:
   (1) Vertical-axis turbines (known as VATs, or egg-beater style) and
   (2) Horizontal-axis turbines (propeller-style).

Horizontal-axis wind turbines are most common today, constituting nearly all of the *utility-scale* (100 kilowatts (kW) capacity and larger) turbines in the global market. Figure 1 shows a typical utility scale wind turbine along with operational data.

- Tower Height: ~328 ft
- Rotor Diameter: ~ 361 ft
- Rated Capacity: ~ 3 MW
- Cut-in wind speed: ~6.8 kts
- Cut-out wind speed: ~52 kts
- Rated wind speed: 27 kts
- Rotor speed: 8. 5 – 15.3 rpm
- Blade tip speed: ~170 kts

Figure 1. State-of-the-art wind turbine and offshore wind farm.

b. Wind Turbine Subsystems. Primary components include the following.
   (1) A rotor, or blades, which convert the wind's energy into rotational shaft energy.
   (2) A nacelle (enclosure) containing a drive train and usually a gearbox and a generator.
   (3) A tower, to support the rotor and drive train.
   (4) Electronic equipment such as controls, electrical cables, ground support equipment, and interconnection equipment.
   (5) Wireless remote controls

Wind turbines vary in size from small business and residential units that are in the 60 to 120 foot range (50 to 500 kilowatts of generating capacity) to current utility scale state-of-the-art units that are capable of generating 3 megawatts of electricity and are almost 500 feet tall at the maximum blade tip height. Offshore turbines can be even larger. The most economical application of wind electric turbines is in groups of large machines called *wind power plants* or *wind farms*, which often include scores or hundreds of wind turbines. The electricity generated by a utility-scale wind turbine or wind farm is normally collected and fed into utility power grid, where it is mixed with electricity from other power plants and then distributed to utility customers.

3.2 Solar Energy. A variety of technologies convert sunlight to usable energy. The most commonly used solar technologies for homes and businesses are solar water heating, passive solar design for space heating and cooling, and solar photovoltaic (PV) for electricity. Solar PV and concentrating solar power (CSP) technologies are used for utility scale power plants. The PV technology converts sunlight directly into electricity using specially designed panels. PV

plants, like the one at Nellis Air Force Base (AFB) shown in Figure 2, are typically no more than 50 feet high and are considered a low threat with regard to glint and glare for aircrews. The CSPs use the heat from the sun to generate steam that powers conventional turbines, and use significant amounts of water, which can be problematical in arid areas. There are three types of CSPs; they are solar troughs, solar power towers, and Stirling engines. A Stirling engine is shown in Figure 3. Troughs and Stirling engine plants are normally less than 50 feet tall. Power towers are typically over 500 feet tall. A new type of power tower being proposed could be several thousand feet tall (Figure 4 shows a prototype concept). All solar plants require large, flat areas of land that are totally cleared of any vegetation and that are periodically treated with herbicides.

Figure 2. Nellis AFB Photovoltaic Solar Facility.

Figure 3. Stirling engine solar facility.

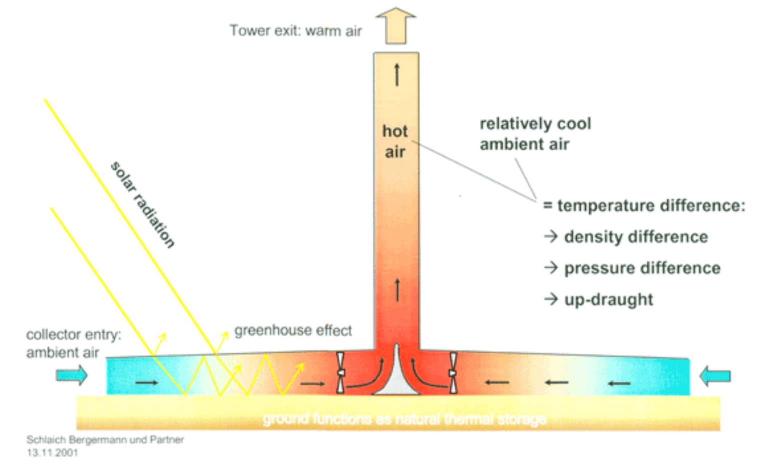


Figure 4. Solar chimney concept.

3.3 Geothermal. Geothermal energy is energy derived from the natural sources of heat inside the Earth. Naturally occurring hot water or steam is converted into electricity. At the Earth's core, temperatures can reach over 9,000° F. This heat continuously flows outward and is absorbed by the rocks and water deep underground. The most common way of capturing the energy from geothermal sources is to tap into naturally occurring *hydrothermal convection* systems where cooler water seeps into the Earth's crust, is heated up, and then rises to the surface. When heated water is forced to the surface, it is a relatively simple matter to capture that steam and use it to drive electric generators.

Geothermal power plants drill holes into the rock to more effectively capture the steam. There are three designs for geothermal power plants, all of which pull hot water and steam from the ground, use them, and then return them as warm water to prolong the life of the heat source. In the simplest design, the steam goes directly through the turbine, then into a condenser where the steam is condensed into water. In a second approach, very hot water is depressurized or flashed into steam which can then be used to drive the turbine. In the third approach, called a binary system, the hot water is passed through a heat exchanger, where it heats a second liquid (such as isobutane) in a closed loop. The isobutane boils at a lower temperature than water, so it is more easily converted into steam to run the turbine.

Geothermal power plants have the smallest footprint of any form of renewable energy in terms of surface area used per unit of energy produced, and typically have fewer adverse impacts on species and habitat than any other kind of renewable energy, although some impacts on groundwater can be experienced.

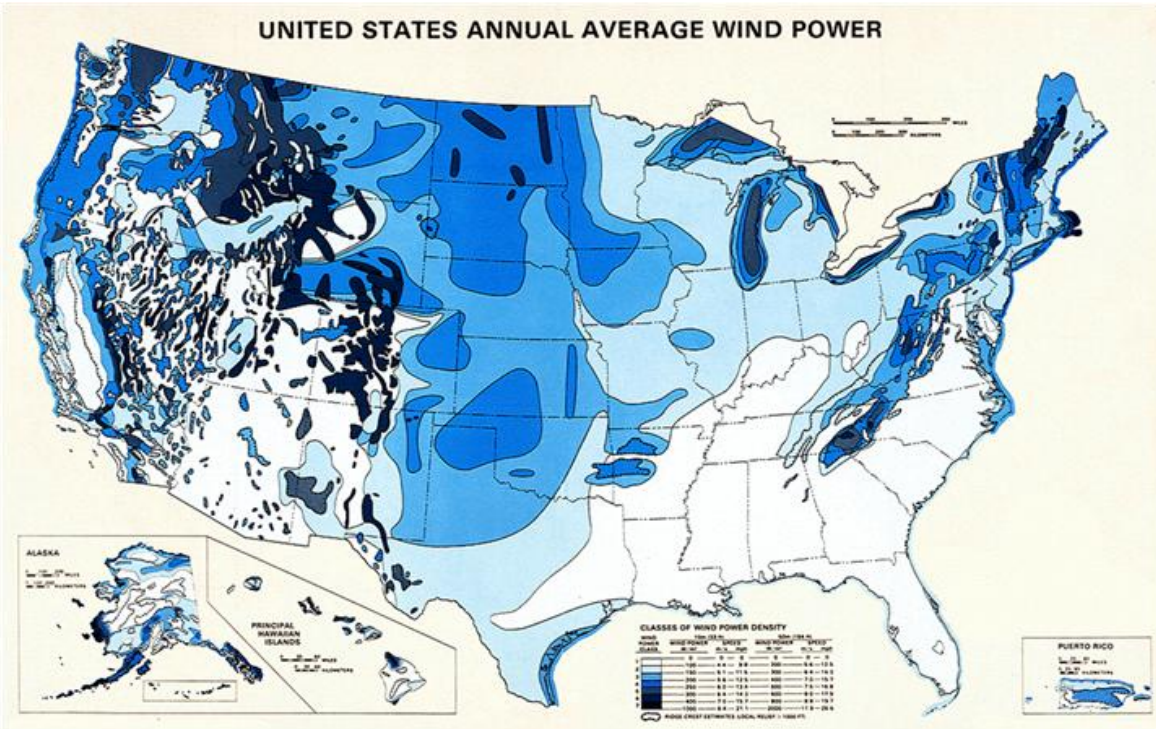
3.4 Biomass to Energy. Biomass power is power obtained from the energy in plants and plant-derived materials, such as food crops, grassy and woody plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes. Biomass can be an

attractive petroleum alternative because it is a renewable resource that is more evenly distributed over the Earth's surface than finite energy sources, and may be exploited using more environmentally friendly technologies. Biomass can have adverse ecological impacts depending on the type of feedstock used, whether ecologically diverse habitats are converted to monoculture production of feedstocks, and impacts on water quantity or quality either through increased demand or through release of increased release into water systems of nutrients such as nitrogen or phosphorus used in connection with growing biofuel feedstock.

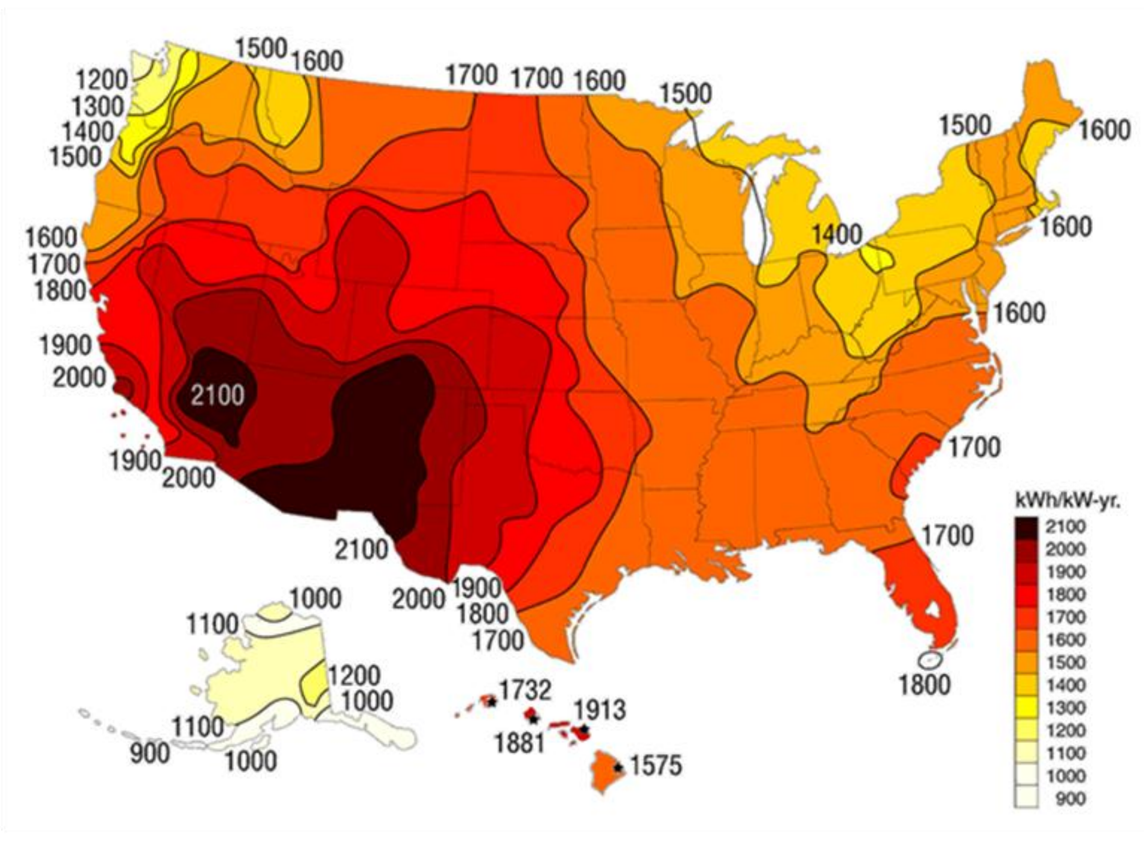
3.5 Hydro Energy. Hydro energy is using the energy of flowing water to generate power. The force of water, as it flows from a higher to lower elevation, converts kinetic energy into mechanical energy. This mechanical energy is used to rotate turbines connected to a generator that converts the energy into electricity. Aside from a plant for electricity production, a hydropower facility consists of a water reservoir enclosed by a dam whose gates can open or close depending on how much water is needed to produce a particular amount of electricity. Hydro energy is used to produce more electricity than other renewable methods of electricity generation in the U.S. The U.S. has about 80,000 MW of conventional hydro energy capacity and 18,000 MW of pumped storage. As with other renewable energy production, hydropower can also have adverse ecological impacts, including interruption of the natural ecological flows of a river system, impeding up and downstream movement of fish and other aquatic species, severance of floodplains from river systems with resulting disruption in nutrient refreshment, and other similar impacts.

3.6 Tidal, Current and Wave. Tidal variation, ocean currents and waves, and, to some extent, rivers can be used to generate electricity. Tidal energy is produced through the use of tidal energy generators. Large underwater turbines are placed in areas with high tidal movements, and designed to capture the kinetic motion of the ebb and flow of ocean tides to produce electricity. Current generators are similar. Wave generators utilize the constant up and down movement of the ocean to power generators.

3.7 Available Renewable Resources. One common aspect of most renewable energy plants is that they must be located where there is a readily available renewable resource. Wind farms must be built where the wind blows enough to make the plant economically viable. Figure 5 shows where wind and solar resources are located based on currently available data. Other factors, such as environmental, operational and land use restrictions, land and water availability, and especially proximity to and access to transmission lines drive where renewable energy plants are built, but these maps provide a good indicator and it is in those high resource areas that plants are being planned and developed.



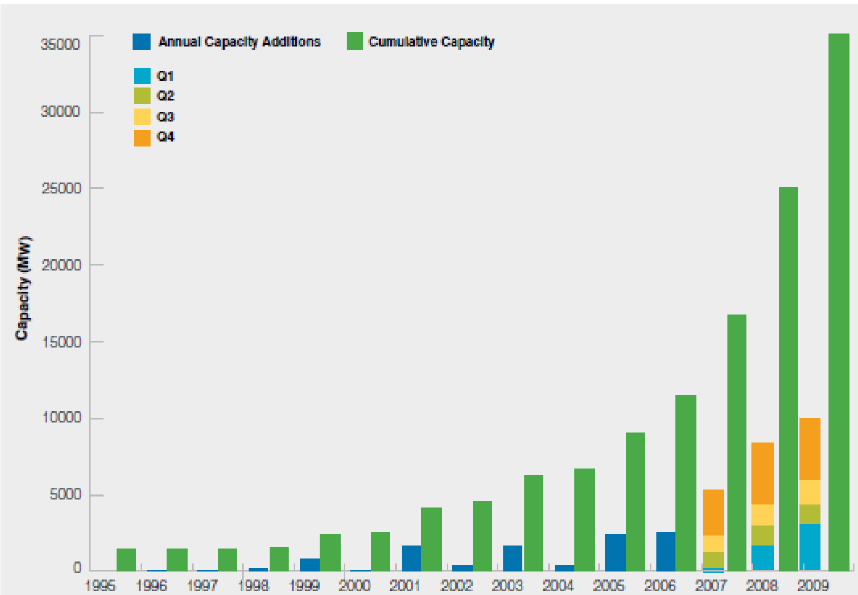
Source: *http://www.nrel.gov/rredc*



Source: *Solar Energies Association*

Figure 5. U.S. Annual average wind power and solar resources.

3.8 Trends. There is no question that renewable energy is on the rise in this country and around the world. Figure 6 shows the growth of wind energy generation in the U.S. In 2009, over 10,000 MW of generation capacity was added bring the total to over 35,000 megawatts. Newly installed capacity in 2010 was about half the increase in 2009, at approximately 5,115 MW. The total installed capacity is just over 40,000 MW, about 1.8 percent of all electric power generation in the U.S. According to the American Wind Energy Association (AWEA) the pace is increasing. Offshore wind energy, particularly off the Mid-Atlantic coast, is expected to grow significantly in the near to mid-term. Depending on the development of commercially viable deep water technologies, offshore wind off the Pacific coast may also be used in the years ahead. The primary reasons may include the proximity to significant load centers (urban areas on or close to the shoreline) and simpler resolution of complex issues related to new transmission infrastructure, which is often a limiting factor for development on land.



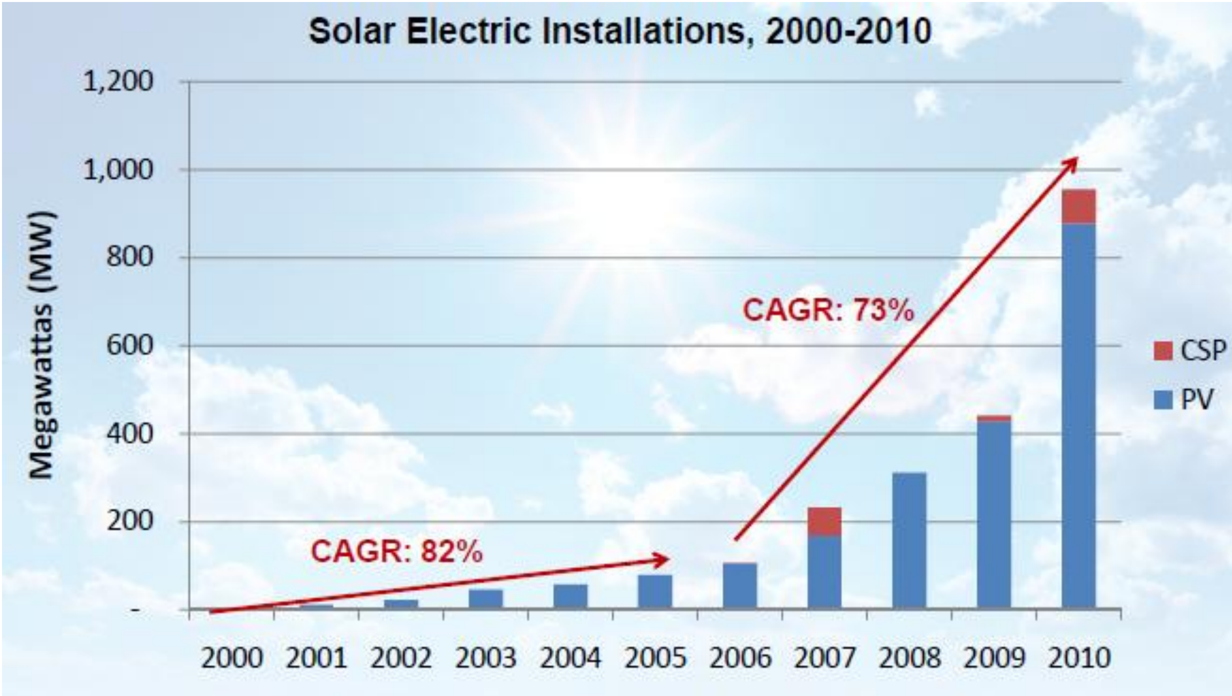
Year	Annual Capacity Additions (MW)	Cumulative Capacity (MW)
Through end 1995		1416
1996	1	1417
1997	17	1434
1998	140	1574
1999	819	2394
2000	67	2460
2001	1691	4151
2002	412	4563
2003	1670	6233
2004	397	6629
2005	2385	9014
2006	2462	11476
2007	5258	16725
2008	8366	25076
2009	10010	35086

Installation figures for years 2006 - 2009 (annual and cumulative) include capacity for installed turbines under 100 kW, whereas earlier years may not. The small wind report tracks sales of wind turbines 100-kW and below. The utility scale wind power projects database tracks turbine installations 100-kW and above. 100-kW turbine sales were subtracted from the small wind report total to avoid double counting. Data has changed slightly from the 2008 Wind Industry Report due to small decommissionings, changes in how the data was reported and other changes provided by companies.

Source: American Wind Energy Association U.S. Wind Industry Annual Market Report – Year Ending 2009

Figure 6. U.S. Wind energy generation capacity.

Total U.S. solar electric capacity from photovoltaic (PV) and concentrating solar power (CSP) technologies climbed past 2,000 MW, enough to serve more than 350,000 homes. See Figure 7. A doubling in size of the residential PV market and three new CSP plants helped lift the U.S. solar electric market 37 percent in annual installations over 2008 from 351 MW in 2008 to 481 MW in 2009. Another sign of continued optimism in solar energy: venture capitalists invested more in solar technologies than any other clean technology in 2009. In total, $1.4 billion in venture capital flowed to solar companies in 2009.



Source: Solar Energy Industries Association

Figure 7. U.S. Cumulative solar capacity growth.

4 Planning Efforts

Several planning efforts to facilitate renewable energy development are either underway or have been completed. The scope of these efforts is typically statewide or regional in scope. Some examples are given below.

a. Wind Energy Programmatic Environmental Impact Statement (PEIS). This PEIS was prepared by the Bureau of Land Management (BLM) to facilitate the approval of wind energy projects on BLM land in eleven Western states. The Record of Decision (ROD) was signed in 2005. It includes a provision that addresses potential military mission impacts and allows BLM denial of an application based on those impacts. The PEIS is available at http://windeis.anl.gov/.

b. West-wide Energy Corridor PEIS. This PEIS was completed in 2009; the purpose is to facilitate approval and construction of transmission lines on federal lands in eleven Western states to connect renewable energy to load centers. The PEIS is available at http://corridoreis.anl.gov/.

c. Solar Energy PEIS. Scheduled for completion in 2011, this PEIS will facilitate approval and construction of solar energy facilities on BLM land in the Southwest. The draft PEIS is available at http://solareis.anl.gov/.

d. Western Renewable Energy Zones (WREZ). The WREZ is an effort by the Western Governors Association to identify renewable energy zones in eleven Western states

and the corridors to bring energy produced therein to load centers. The Phase I report was completed in 2009.

e. California Renewable Energy Transmission Initiative (RETI). The RETI is similar to the WREZ effort (except for California). The RETI recommendations were used in the WREZ study.

f. DoD Involvement. Involvement by DoD in these efforts is critical to ensuring the military mission is addressed and DoD was represented on all of the above. Our involvement does not guarantee our mission will be completely protected, but ensures decision makers have the necessary information on potential impacts.

5 Processes

The processes for planning, review, and approval of renewable energy projects vary with location, type of project, size, and even the technology. On federal land, the agency controlling the land, such as the BLM or the U.S. Forest Service (USFS), has final authority. On private land, the local city or county typically has jurisdiction, with state agencies having concurrent or primary jurisdiction in cases of projects exceeding a specified size. In some states, local zoning ordinances govern the size and location of plants, but many states do not have zoning laws. These zoning and land use ordinances offer an attractive means for local commanders to raise awareness of DoD concerns with these technologies. Public utility commissions, energy commissions and other agencies are often involved in the process. For plants involving structures 200 feet or higher, near an airport, or with potential impacts on air navigation radar, the Federal Aviation Administration (FAA) gets involved through the Obstruction Evaluation/Airport Airspace Analysis (OE/AAA) process.

Developers must obtain a right of way (ROW) to build renewable energy projects on land under the jurisdiction of BLM or a special use permit for energy projects on land under the jurisdiction of the USFS (including National Grasslands). After receiving a ROW or Special Use Permit application, the federal agency involved (typically, BLM or the USFS) and other federal agencies review it and using the National Environmental Policy Act (NEPA) process make a decision whether or not to grant the ROW or Special Use Permit. On private lands, the process varies depending on the jurisdiction. Some jurisdictions require zoning changes or NEPA like environmental reviews. Other jurisdictions have designated renewable energy zones in their general plans so that approval of new projects is a relatively streamlined process. Many have no policies in place. Depending on the potential impacts of a proposed project, processes under the Endangered Species Act (ESA), the Clean Water Act (CWA), the Coastal Zone Management Act (CZMA), the National Historic Preservation Act (NHPA), and other federal or state regulatory statutes may also apply.

5.1 BLM-DoD Wind Generated Energy Facility (WGEF) Protocol. Signed in July 2008, the Protocol requires DoD review of all proposed wind energy projects on BLM lands. The Protocol establishes a 45 day timeline for the review and has a DoD option to request a 45 day extension. Action is initiated at the local level. The protocol includes a dispute resolution process if agreement cannot be reached at the local level. Currently, internal DoD review processes do not consider all potential impacts of projects that in turn could impact DoD operations. For example,

internal DoD review processes do not consider potential impacts on species of concern to DoD. Potentially problematic is the failure to consider impacts on candidate species of concern to DoD, since BLM is not required to conduct its own Endangered Species Act (ESA) analysis or consultation with regard to candidate (as distinct from listed) species.

5.2 Offshore Projects. States have jurisdiction out to three nautical miles from shore (and further in the case of some states) and the processes for review and approval of renewable energy projects are as varied as they are on land. Beyond state waters is federal jurisdiction. The Department of the Interior (DOI), Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), the U.S. Army Corps of Engineers (USACE), and the U.S. Coast Guard (USCG) have jurisdiction, with DOI having the primary jurisdiction. The National Oceanic and Atmospheric Agency (NOAA) also has a role with regard to potential impacts on marine mammals and other protected marine species. There is a Memorandum of Agreement (MOA) between DOI and DoD to address mutual concerns on the Outer Continental Shelf (OCS). In 2009, DoD provided an assessment of proposed OCS oil and gas exploration and production, including areas in which such activities would be incompatible with military activities. The assessment also included site specific stipulations in other areas if oil and gas exploration and production are approved. The recommendations were accepted by DOI.

5.3 DoD Clearinghouse. The Office of the Secretary of Defense (OSD) has established a clearinghouse to ensure consistent DoD responses on proposed renewable energy projects. Section 358 of the 2011 National Defense Authorization Act (NDAA) establishes timeframes for Clearinghouse review of certain existing and new projects (those requiring the OE/AAA FAA review) as well as standards and criteria concerning determinations of adverse impacts on DoD. Policies and procedures are being developed, but the Clearinghouse will be involved in review of all utility scale renewable energy projects and have final decision authority on projects that would present an "unacceptable risk to national security." Regional processes, led by the DoD Regional Environmental Coordinators (RECs) are being established to provide regional coordination among all the services. The model for these teams is the DoD Southwest Renewable Energy Work Group (SREWG), a joint multi-state group formed in 2003. This group coordinates review of all renewable energy projects across all services to ensure consistency and a *one voice* approach is utilized to respond to potential mission impacts.

6 Mission Impacts

6.1 Wind Energy.

a. Airspace. Development of wind farms could have the following impacts on low-level aviation testing and training:
   (1) Turbines associated with wind farms create avoidance areas and require units to abandon the lower altitudes of military training routes (MTRs) and special use airspace (SUA). Turbine heights can reach well over 400 feet above ground level (AGL) and wind farms can cover thousands of acres of land, requiring pilots to traverse the farm above the lower limits of the airspace.
   (2) Wind turbines impact airborne radar by causing false returns (via Doppler shift) which could be an impact during training missions.

(3) This Doppler affect causes significant concerns for the DoD test community, as validating airborne radar system in a cluttered environment is virtually impossible. Siting is a critical component in securing clutter-free airborne radar test areas.
(4) Wind turbines can affect weapons and communications systems prone to electromagnetic interference.
(5) Large farms could impact helicopter turf routes and other non-published training airspace. Loss of the lower altitudes over thousands of acres may require aircraft to transition at a higher altitude, impacting low-level training.
(6) The larger farms with taller turbines can impact low-level night vision training.

b. <u>Ground-based Radars</u>. Wind turbines impact ground-based radar systems in three ways:
(1) The large radar cross-section of the reflections from windmills can cause radar receivers to be driven to saturation. Also, other processing functions can exhibit nonlinear behavior. These effects reduce, or even eliminate, the ability of the radar to detect targets near and within the wind farm area and negatively impact test and training.
(2) The second characteristic of wind farm interference with radar performance is the Doppler shift caused by the turning blades. The velocity of the windmill turbine blade is dependent on the distance from the center of the turbine hub, with an increasing shift moving from the center to the tip of the blades. Thus, the rotating blades produce a continuous spectrum of frequency shift with much of the spectrum falling within the Doppler limits that air surveillance radars are optimized to detect.
(3) Wind turbines are capable of causing range tracking instrumentation to lose lock on airborne test items by providing a larger, more attractive target than the test item. This could have catastrophic consequences on test integrity and safety.

In most cases, wind turbines must be in the line of sight of a radar to impact it. However, there are situations in which turbines can cause problems even if they are out of line of sight.

Instrumentation radars and radar cross section measurement systems may be particularly prone to interference. Mitigating measures, such as receiver modifications or limiting coverage areas, could degrade test and training capabilities.

c. <u>Airborne Systems</u>. Wind turbines have the same types of impacts on airborne radars as they do for ground based systems. However, terrain isn't much of a factor (since the airborne systems are at some altitude above ground) so turbines will be in line of sight of airborne systems.

d. <u>Groundspace</u>. Large wind farms on BLM lands used by the DoD to meet training requirements can impact ground maneuvers. The loss of this land will require the units to locate new maneuver space suitable to meet training requirements. Use of new lands will require environmental documentation in support of the training.

e. Seaspace. In addition to the impacts previously described, wind turbines could impact sea lanes, submarine transit lanes, coastal test and training ranges, and may even ensonate the surrounding sea area and compromise sonar test and training.

f. Habitat and Species. Wind projects either on non-DoD lands or on DoD lands can result in direct mortality to birds and bats, can lead to avoidance behavior in ground-nesting birds such as sage grouse, can fragment habitat and disrupt seasonal migration patterns, and can directly destroy occupied or unoccupied habitat for species. Such impacts on listed, candidate, or otherwise sensitive species or habitat (whether or not occupied by the species concerned) also found on DoD lands can have significant second-tier effects on DoD by increasing over time ESA-related restrictions on DoD operations, especially ground operations.

6.2 Solar Energy. Solar farms can have multiple impacts on test and training.

a. Solar thermal plants can have a very high thermal signature and may interfere with infrared (IR) sensors. These IR sensors can actually lock onto the solar plant and should be considered in/around ranges that use IR technologies.

b. The type of solar used can impact SUAs, MTRs and areas utilized by the military for ground maneuverability training.

c. Large solar farms using panels can reduce available ground training space.

d. Solar projects using towers can reach heights of over 2000 feet AGL. This type can impact all types of airspace. The FAA requires all structures above 199 feet AGL to be sent through the OE/AAA office for determinations of impact to aviation.

e. Solar energy facilities sometimes utilize wireless control systems that can interfere with or be interfered by DoD systems.

f. Solar facilities cause reflectivity from the sun. This phenomenon is known as glint (instantaneous flash) and glare (continuous blinding) and can be quite severe depending on the type of facility and angle from the sun/exposure time. Glint/glare from nearby solar facilities should be considered from a safety of flight and eye exposure perspective on DoD ranges.

g. Solar thermal plants can consume large amounts of water, which could impact an installation's and the regional water supply both in terms of quality and quantity. Especially in arid regions, this impact on water supplies, and especially on groundwater, can in turn have severe impacts on species, which can result in second tier impacts through additional restrictions on DoD water usage for other purposes and on increased restrictions on DoD operations under the ESA. In the desert Southwest, the impacts of climate change are expected to significantly decrease water supplies in the future, making impacts on water increasingly significant.

h. Solar plants always destroy habitat, requiring both leveling and total eradication of vegetation, with periodic retreatment with herbicides. If such impacts are not minimized through careful siting, and if sufficient mitigation (whether or not required by existing provisions of law) isn't provided, installations could be put under more ESA or CWA restrictions with resultant constraints on mission capability.

Caution: The FAA requires that all projects above 199 feet AGL be processed through the office of OE/AAA for determination for any hazard to flight and coordinated through the military representative (MILREP) at the FAA's regional office. Coordination of each project may not reach all impacted users. In order to insure you are in the loop it is suggested that your local airspace manager establish a good relationship with the local MILREP and FAA office.

6.3 Transmission Lines. Virtually all renewable energy plants require new transmission lines. Since renewable energy sources are often distant from load centers, long haul transmission lines are being planned to facilitate the construction of renewable energy plants. Transmission lines can have mission impacts such as those described below.

a. Transmission lines and towers can impact SUAs, MTRs, and other low-level aviation missions.

b. Transmission lines emit electromagnetic energy that can impact range systems, especially where electronic warfare testing or training is conducted.

c. Proposed use of electrical transmission lines for broadband wireless may cause additional impacts.

d. Fragmentation of habitat and disruption of migratory patterns as well as other adverse impacts on species and habitat.

6.4 Biomass-to-Energy.

a. Feedstock: sources, storage requirements, and impacts on transportation corridors, on biodiversity resulting from monoculture cultivation of feedstocks, and on water quantity and quality resulting from nutrient runoffs and other impacts. In areas of the Upper Midwest, the Mid-Atlantic, and the Southeast, such impacts can have potentially significant second tier impacts on DoD.

b. Plant: physical footprint, water requirements, stack heights, compatibility with nearby land uses.

c. Emissions: smoke and condensation plume impacts on atmospheric opacity (visual and other spectra), odors, noise, and boiler ash.

d. Management processes to ensure mission equities are accurately mapped out and appropriately considered every step of the way.

NOTE	A compendium of some of the studies, research efforts and testing that have been done or is ongoing to address military mission impacts of renewable energy is being maintained at https://RE-Ref.com. Access to the site is controlled and users will need a login and password.

7 What Can You Do?

Awareness and early engagement are the keys to both ensuring renewable energy projects are mission compatible as well as identifying those that will negatively impact DoD activities. The *Commanders Guide to Community Involvement* provides several strategies that are applicable to all types of encroachment issues, including renewable energy. In addition, local zoning regulations that provide, at a minimum, DoD notification requirements on renewable energy projects are helpful. Another tool is the so-called Red-Yellow-Green or stoplight strategy that can be used as a screening tool or to establish hard limits (such as zoning law). In some cases, the concept has been incorporated into zoning ordinances, e.g. Kern County, California. Proactive engagement with local zoning boards is key to ensuring their land use ordinances accurately reflect DoD interests.

Participation in various groups that address renewable energy encroachment issues is also valuable. The RCC Sustainability Group, the Southeast Regional Partnership for Planning and Sustainability, and the Western Regional Partnership (WRP) are some examples.

Some other lessons learned include:

a. Early engagement and outreach with land use jurisdictions, renewable energy developers, government agencies, industry organizations, and non-governmental organizations (NGOs) engaged on energy issues.
b. Access to a robust Geographical Information System (GIS).
c. Regional engagement with DoD dedicated lead.
d. Coordination between facilities, test and training range managers, and operators
e. Consistent messages.
f. Chain of command communication and coordination with tenant organizations or occasional users from other installations or Services of lands, airspace, and seaspace managed primarily by a single installation or a single Service to ensure that impacts on the missions of those users is also taken into full consideration
g. Installation/range Office of Primary Responsibility (OPR) for alternative energy with access to appropriate subject matter experts (SMEs), including environmental, hydrology, and natural resource staffs.

8 Summary

Development of renewable energy is a major national security issue, but has the potential to significantly impact military testing and training. Compatible development of renewable energy is possible, but requires engagement throughout all levels in the chain of command and thorough coordination between SMEs from operational, facility support, environmental/natural resources, and other relevant stakeholders.

****** NOTHING FOLLOWS ******